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Assessment of the American plaice stock in NAFO Subdiv. 3Ps.

by

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ABSTRACT

Recent research vessel surveys have shown the stock size of American plaice in NAFO subdivision 3Ps to be at its lowest observed level. The stock size is currently only 10% of the average levels observed in the mid 1980's. Although catches may have added to the decline of this stock in recent years, the large decline observed in the late 1980's occurred when catches were low. This stock is well below historic levels, with no immediate prospects of rebuilding.

Résumé

Il ressort des relevés de recherche récents que le stock de plie canadienne dans la subdivision 3Ps de l'OPANO est au plus bas niveau observé à ce jour, soit à seulement 10 % environ des niveaux moyens enregistrés vers le milieu des années 1980. Quoique les prises aient pu contribuer au recul du stock ces dernières années, le fort déclin observé à la fin des années 1980 s'est produit alors que les prises étaient faibles. Ce stock se trouve bien en deçà de ses niveaux antérieurs et n'offre pas de perspectives de rétablissement dans l'immédiat.

Description of the fishery

Catches from this stock were highest from 1968 to 1973, exceeding 12,000 t on three occasions in this period (Fig.1, Table 1). Catches by foreign vessels peaked at about 8800 t in 1968, due mainly to the USSR catch, and have not exceeded 800 t since 1973. Catches by France ranged from 540 t to 760 t from 1986-89, but declined to only 26 t in 1992. There has been no French catch reported since 1992. In 1993, both offshore and inshore catch were the lowest in the time series up to that time (Table 2). This fishery has had a substantial main species plaice component and has often been prosecuted in the first quarter (Table 3). Overall, the catch in 1993 was 751 t, the lowest since the early 1960's. Based on a recommendation by the FRCC the fishery was closed in September of 1993 for the remainder of that year. The TAC for 1994 was set at 500 t to allow a by-catch in other fisheries. Total catch in 1994 was 117 t. 56% of the catch was taken by otter trawl (Table 4). There is a 100 t by-catch quota for 1995.

Available Data

Catch at age and mean weights at age

The catch at age and mean weights at age for this stock have been based on sampling from the Canadian fishery, as no sampling data were available for the French catches. In 1993 the catch was comprised mainly of fish aged 8-12, similar to most years (Brodie et al. 1993), although there was no sampling data from the inshore catch in 1993, which comprised 60% of the catch weight. The mean weights at age in 1993 and 1992 were lower than recent values, due in part to the absence of the inshore sampling. Inshore gear tends to catch larger fish at age so that absence of sampling from this fishery would tend to result in a bias in the mean weights at age.

Catch effort data

A multiplicative analysis of commercial catch rates of American plaice for the Canadian offshore trawler fleet in Subdiv. 3Ps has not been updated since 1993 because of very low catch (main species plaice catch = 48 t) and closure of the fishery in 1993. The analyses of CPUE done in 1993 (Brodie et al. 1993) showed relative stability from 1987 to 1990, at about the same level observed in 1981-83, then a sharp decline to the lowest observed levels in 1991 and 1992. Reports from the fishing industry indicated very poor catch rates in this fishery in 1993.

Research vessel survey biomass and abundance

Stratified-random surveys have been conducted by Canada in Subdiv. 3Ps in each year from 1972 to 1995. There were two surveys in 1993, one in February and one in April. Most of the surveys prior to 1993 were in February, while those since 1993 have been in

April. Tables 5, 6 and 7 show the results from these surveys, and it can be seen that survey coverage was poor in many years prior to 1979. The biomass index (Fig.2) was relatively stable from 1986 to 1988, around 30,000 t, the value from the 1989 survey was substantially lower at 17,000 t, and 6 of the 7 surveys since then have produced estimates less than 7,000 t. It should be noted that there has been a monotonic decline in the biomass index since 1987, with the exception of the 1990-91 points. However, the 1990 survey missed several key strata in Subdiv. 3Ps, including 4 of the 6 strata with the highest densities of A.plaice in the 1991 survey (Table 5). Thus the 1990 survey results are probably underestimated. The 1994 survey gave an estimated biomass index of 4,156 t and the estimate from the 1995 survey is 3,944 t. Tables 6 and 7 reflect the changes made to the stratification scheme in subdivision 3Ps in 1994 and 1995. Most of the biomass in recent surveys was in deeper areas than usual with relatively higher biomass at greater than 150 fathoms since the late 1980's (Table 8).

Age-by-age estimates of abundance from the R. V. surveys are shown in Table 9. The catch numbers at length for the 1977-82 surveys carried out by the A. T. Cameron were adjusted by the appropriate conversion factors to make them comparable with the data from the 1983 to 1993 surveys. The data for 1977-90 were taken from a previous assessment of this stock, which used a multiplicative model to account for strata not surveyed in each year.

Table 9 shows the decline in abundance in this stock in recent years, with the two 1993 surveys being the lowest points in the 18-point series. The abundance of all age groups has declined and there has been a decrease in recruitment. Age-by-age data from the 1994 and 1995 surveys are not yet available. Abundance at length from these surveys does not indicate any increase in young fish (Fig.3).

Data from the French RV surveys in 3Ps also show a decline in abundance through 1992 (Brodie et al. 1993). There have been no French surveys since then.

Age at Maturity

Maturity at age was estimated from RV data for males and females in 3Ps from 1973 to 1993 using the method of Morgan & Hoenig (1993). From these estimates age at 50% maturity was calculated for each sex and year using probit analyses assuming a normal distribution. For both males and females there has been a dramatic decline in age at 50% maturity over the time period examined (Fig.4). For males, the average A_{50} from 1973 to 1982 was 6.67 y while in the 1984 to 1993 period it was 5.33 y with estimates for the last 3 years being less than 5 y. For females,

the average A_{50} from 1973 to 1982 was 10.61 y while in the 1984 to 1993 period it was 8.93 y with estimates in 6 of the last 10 years being less than 9 y. No ageing data is available since 1993.

Index of Female Spawning Stock Biomass

An index of female spawning stock biomass was constructed from the r.v. survey data. Mean length at age for females was calculated for each age in each year from 1973 to 1993. A length weight relationship for females was calculated for each year from 1990 to 1993 and applied to the mean lengths at age to calculate mean weight at age. An average length weight relationship was also calculated for the 1990 to 1993 period and applied to all years prior to 1990, a period for which there is no individual weight data. Female spawning stock biomass was then calculated for each year using the mean weight at age, abundance at age and estimated proportion mature at age. Some caution should be taken in interpreting results prior to 1977 because of poor survey coverage in many of these years (Table 5). Female spawning stock biomass reached a peak at 37,000 t in 1985 (Fig.5) and has been declining since. The 1993 estimate of 1,900 t is the lowest since 1975. The female spawning stock biomass averaged 28% of the total biomass from 1973 to 1982. In the last 10 years it has averaged 51% of the total biomass. This is a result of increased proportion mature at age and low numbers of young fish.

Sequential Population Analyses (SPA)

SPA results have not been presented for this stock since 1991, when various formulations of the Adaptive framework were attempted (Brodie 1991). The results of these SPA's were not acceptable, due to strong year effects in the residuals, an unexplained u-shaped pattern in the slopes of the calibration coefficients (q's) by age, and a substantial discrepancy in the results using RV survey data compared to the results using commercial CPUE at age data. In addition, the RV survey estimates of abundance were quite variable in the 1989-1992 period, and the VPA calibrations were sensitive to these fluctuations. Given these problems, along with difficulties in calculating catch at age for 1993-94, SPA has not been used as the basis for the assessment of this stock in recent years.

We explored a more intuitive alternative to tuned VPA. Basically a VPA works by reconstructing the history of finished cohorts from catch data, and then using them to calibrate abundance indices for active cohorts. The catch history of the active cohort is then used to infer, say, its recruitment. Each finished cohort, and each age at which the calibration can be done, yields a separate estimate of the active cohort's recruitment. The variation in the separate estimates can then be displayed, as can any systematic dependence on things like the age of calibration or the

finished cohort from which it was calibrated.

Figure 6 shows the quartiles of all estimates of recruitment (age 6) of the active cohorts at the beginning of 1995 (taking age 19 as the oldest age of non-zero numbers). This was based on research vessel surveys from 1977 to 1993. Also shown is the recruitment estimated by the tuned VPA in the 1991 assessment document, which used surveys from 1977 to 1990. There is a clear discrepancy; the tuned VPA shows a much earlier decline in recruitment (Fig.6). The reason seems to be that the most recent (1990) survey in the VPA tuning was anomalously low (Table 9), as was noted in the earlier discussion of RV survey results. Although the plot of quartiles is presented as if every estimate had equal weight, in fact estimates based on calibrating at older ages (thus from more recent surveys for the active cohorts) should have less variance and therefore greater weight. The reason for this is that for the estimates calibrated at older ages, more of the recruitment estimate comes from the reconstructed catches, which are assumed in all of these analyses to be without error; and only a small part comes from the calibration of error-prone survey indices. Moreover, in the usual ADAPT tuning, low surveys are assumed to be more accurate. Taking account of surveys since 1990 gives a less extreme picture.

Discussion

Similar to other stocks of A. plaice in the Nfld. & Labrador area, 3Ps plaice has declined markedly since the mid to late 1980's and is now at a level well below that of the early to mid 1980's. This is confirmed by all 3 indices (Canadian RV surveys up to 1995, French RV surveys up to 1992, and Canadian OT CPUE (1974-1992)), and by declines in the fishery. Recent surveys have shown no indication of recovery. Abundance at all ages has declined and it appears that recruitment has been low since the mid to late 1980's. There has been an increase in the proportion mature at age since that time, but this has not halted the decline in female spawning stock biomass.

As a proxy for the exploitation rate on the stock, the ratio of catch to trawlable biomass from surveys for the period 1983-93 was examined (Fig. 7). Both total catch and offshore catch only were used to calculate the ratios, as it was thought that the offshore catch was more comparable to the survey biomass index, in that both exclude plaice in the inshore areas. From 1983 to 1989, the annual ratio of catch to trawlable biomass was less than 10%, although the stock size declined substantially during this time. In the early 1990's, with the stock at a very low level, the catch to biomass ratio increased to levels much higher than those seen in the 1980's, then declined in 1993-94 with the large reductions in the fishery (Fig. 7). Thus it appears that during 1980's, when the major decline in stock size occurred, commercial catches were

unlikely to have been the major cause. However, in the early 1990's the catch to biomass ratio increased, and this may have accelerated the further decline in stock size.

The increasing trend in standardized fishing effort (Fig. 8) also suggests that exploitation increased in the early 1990's. This effort index in 1991-92 was about 3-4 times higher than it was in the early 1980's, whereas the stock size in the early 1990's was substantially lower than in the earlier period. Recent assessments have also indicated that fishing mortality probably increased in the late 1980's and early 1990's, although it was not possible to quantify the magnitude of the increase (Brodie et al. 1993).

Outlook

The outlook is very pessimistic, given the current low stock size, and the lack of recruitment indicated by the surveys. In the short to medium term, there is no prospect for stock rebuilding.

References

Brodie, W.B. 1991. An assessment of the American plaice stock in NAFO subdivision 3Ps. CAFSAC Res. Doc. 91/72, 30 p.

Brodie, W.B., D.Power, and W.R.Bowering. 1993. Assessment of the American plaice stock in NAFO Subdiv. 3Ps. DFO Atlantic Fisheries Research Document 93/24, 22 p.

Morgan, M.J. and J.H.Hoenig. 1993. Maturity at age from length stratified sampling. ICES C.M. 1993/D:55 ref. G. 11p.

Table 1. Catches (1960-94) and TACs (1974-95) of American plaice in NAFO Subdivision 3Ps. All values in metric tons.

	Canada							
Year	Nfld	M&Q	Total	France	USSR	Other	Total	TAC
1960	422	405	827	60	-	-	887	-
1961	764	660	1,424	31	-	-	1,455	-
1962	659	363	1,022	2	-	-	1,024	-
1963	504	25	529	208	1	16	754	-
1964	1,132	230	1,362	152	-	28	1,542	-
1965	574	1,275	1,849	162	-	11	2,022	-
1966	1,162	1,332	2,494	667	218	27	3,406	-
1967	2,201	1,074	3,275	533	678	8	4,494	-
1968	4,007	1,516	5,523	524	8,233	-	14,280	-
1969	2,888	1,178	4,066	245	2,180	-	6,491	-
1970	7,368	4,227	11,595	397	336	-	12,328	-
1971	4,667	1,286	5,953	820	409	-	7,182	-
1972	4,301	1,621	5,922	383	220	13	6,538	-
1973	10,972	1,840	12,812	547	1,368	42	14,769	-
1974	5,887	443	6,330	268	-	-	6,598	11,000
1975	2,517	1,301	3,818	65	128	200	4,211	11,000
1976	5,302	128	5,430	5	9	14	5,458	8,000
1977	4,235	307	4,542	63	-	-	4,605	6,000
1978	3,419	192	3,611	47	-	-	3,658	4,000
1979	3,405	187	3,592	74	-	-	3,666	4,000
1980	2,516	213	2,729	206	-	-	2,935	5,000
1981	2,703	57	2,760	457	-	-	3,217	5,000
1982	1,823	46	1,869	317	-	-	2,186	5,000
1983	1,421	83	1,504	222	-	-	1,726	5,000
1984	2,487	138	2,625	338	-	-	2,963	5,000
1985	3,608	206	3,814	406	-	-	4,220	5,000
1986	4,367	98	4,465	665	-	-	5,130	5,000
1987	4,669	119	4,788	543	-	-	5,331	5,000
1988	3,745	56	3,801	605	-	-	4,406	5,000
1989	3,102	96	3,198	759	-	-	3,957	5,000
1990[a]	3,904	226	4,130	-	-	-	4,130	4,000
1991[a]	4,043	480	4,523	-	-	-	4,523	4,000
1992[a]	2,305	-	2,305	26	-	-	2,331	4,000
1993[a]	694	57	751	-	-	-	751	3,000
1994[a]	109	8	117	-	-	-	117	500[b]
1995	-	-	-	-	-	-	-	100[b]

[a]Provisional
[b]By-catch

Table 2. Catches by Canadian vessels, 3Ps American plaice, 1972-94.

Year	Gear							
	Seine	Gillnet	Longline	Other	Subtotal	Ottertrawl	Unk.	Total
1972	11	174	143	7	335	5,587		5,922
1973	63	233	212	17	525	12,287		12,812
1974	3	195	235	20	453	5,877		6,330
1975	62	322	127	63	574	3,244		3,818
1976	28	245	44	13	330	5,100		5,430
1977	140	291	119	17	567	3,975		4,542
1978	65	256	185	29	535	3,076		3,611
1979	117	292	176	13	598	2,994		3,592
1980	17	373	266	15	671	2,058		2,729
1981	84	671	370	19	1,144	1,616		2,760
1982	35	265	199	4	503	1,366		1,869
1983	9	113	219	9	350	1,154		1,504
1984	-	86	102	15	203	2,422		2,625
1985	2	118	273	6	399	3,415		3,814
1986	10	887	354	12	1,262	3,203		4,465
1987	20	1,650	300	50	2,020	2,768		4,788
1988	9	1,089	225	21	1,344	2,457		3,801
1989	-	1,071	190	30	1,291	1,892		3,198
1990[a]	-	738	295	10	1,043	3,087		4,130
1991[a,b]	26	1000	220	31	1,277	3,246		4,523
1992[a]	11	587	133	15	746	1,559		2,305
1993[a]	20	353	51	41	465	286		751
1994[a]	11	38	-	3	52	65		117

[a]Provisional.

[b]Includes 480 t of unspecified flounder reported in 3Ps by Canada Maritimes assumed to be A. plaice.

Table 3. Nominal catch by month, American plaice in Subdivision 3Ps, 1972-94.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	UNK	Total
1972	1,118	105	311	161	110	109	391	520	604	880	1,044	1,185	-	6,538
1973	1,681	500	2,599	1,527	96	350	969	2,607	931	504	2,237	768	-	14,769
1974	162	133	1,576	2,575	123	137	165	399	567	128	364	269	-	6,598
1975	6	6	1,495	616	332	280	186	115	120	82	441	532	-	4,211
1976	98	254	461	191	91	284	439	512	353	433	984	1,358	-	5,458
1977	28	547	663	339	309	287	414	204	105	261	712	736	-	4,605
1978	250	141	185	1,066	853	121	433	427	40	41	55	46	-	3,658
1979	467	376	1086	212	189	262	225	265	124	161	246	53	-	3,666
1980	14	464	180	63	216	359	166	170	170	191	256	686	-	2,935
1981	423	57	236	371	363	331	302	156	214	263	273	228	-	3,217
1982	53	4	285	315	181	156	133	195	125	95	463	181	-	2,186
1983	98	47	161	71	61	155	169	91	327	372	149	25	-	1,726
1984	128	1,933	101	43	125	126	85	60	31	194	94	43	-	2,963
1985	3	55	2,814	240	35	154	134	80	199	146	343	17	-	4,220
1986	1,960	447	500	52	149	334	444	493	302	275	91	83	-	5,130
1987	455	260	1,312	349	241	512	711	581	200	189	250	271	-	5,331
1988	236	714	389	73	130	509	805	363	342	263	341	241	-	4,406
1989	118	273	509	269	234	547	737	336	220	252	301	161	-	3,957
1990[a]	290	394	1,652	258	135	341	312	437	205	65	14	27	-	4,130
1991[a,b]	46	453	471	195	324	552	637	546	517	449	147	786	-	4,523
1992[a]	356	432	213	262	111	229	245	154	99	161	27	16	26	2,331
1993[a]	30	164	73	3	57	79	157	123	33	18	10	4	-	751
1994[a]	0	0	15	38	16	18	12	4	1	5	4	4	-	117

[a]Provisional.
[b]Unspecified flounder reported in 3Ps by canada Maritimes assumed to be A. plaice.

Table 4. Catch of A. plaice in Subdiv. 3Ps in 1994. Entries are Can (N) + Can (SF).

	OT	Seine	GN	LL	Other	NFLD	SF	Total
Jan								0
Feb								0
Mar	15							15
Apr	31	6			1			38
May	7		9					16
Jun	1		17					18
Jul		1	11					12
Aug	1		1		2			4
Sep	1							1
Oct	4	1						5
Nov	2	2						4
Dec	3	1						4
						109	8	
Total	65	11	38		3			117

Table 5. Mean weight (kg) of American plaice per tow, by stratum, from r.v. surveys in Subdivision 3Ps. Numbers in parentheses are the number of successful 30-minute tows in each stratum. The stratified mean weight per tow and the biomass estimates are given at the bottom of the table. (ATC, AH, WT, refers to the research vessels, A.T. CAMERON, A. NEEDLER, and W. TEMPLEMAN respectively.)

Depth (fm)	Stratum	No. of trawl units ('000)	Year - Survey 1972 ATC 197	1973 ATC 207	1974 ATC 221	1975 ATC 234	1976 ATC 247	1977 ATC 261	1978 ATC 273	1979 ATC 287	1980 ATC 302	1981 ATC 316	1982 ATC 330
101-150	306	31.452	-	-	0.3(6)	0.4(4)	0.6(2)	0.5(6)	1.0(6)	1.4(5)	1.1(2)	0.6(3)	0.5(3)
51-100	307	29.650	0.0(3)	0.0(5)	1.9(7)	0.4(4)	1.4(4)	1.1(4)	0.1(4)	0.1(4)	1.6(2)	0.9(3)	2.5(4)
31- 50	308	8.407	-	0.7(2)	28.1(2)	17.3(4)	16.3(2)	18.8(4)	-	0.7(4)	4.0(2)	306.5(2)	49.3(2)
101-150	309	22.219	0.0(2)	1.2(3)	0.1(4)	2.6(6)	0.5(3)	1.1(6)	1.3(6)	3.9(6)	0.7(2)	1.5(2)	0.4(2)
101-150	310	12.761	-	-	0.2(3)	1.5(6)	-	0.3(6)	0.5(6)	1.7(6)	3.0(2)	3.0(2)	1.0(3)
51-100	311	23.795	8.1(4)	109.1(9)	13.4(8)	8.8(4)	12.6(6)	3.9(4)	5.9(4)	40.4(4)	108.5(2)	10.0(2)	2.7(3)
31- 50	312	20.417	249.5(2)	-	43.3(2)	18.4(3)	20.6(5)	12.5(4)	-	0.1(3)	-	1.2(2)	5.3(2)
101-150	313	12.386	0.5(2)	168.3(2)	0.7(5)	0.4(3)	1.2(3)	0.5(10)	4.1(2)	4.0(5)	2.6(2)	21.5(2)	1.2(2)
0- 30	314	73.113	28.6(2)	-	0.2(2)	-	1.1(2)	16.3(4)	-	-	0.5(2)	0.3(5)	23.3(5)
31- 50	315	62.078	71.7(2)	48.3(2)	103.0(2)	-	32.7(2)	27.2(4)	-	5.3(3)	48.1(4)	33.0(2)	53.5(3)
101-150	316	14.187	3.2(2)	23.0(3)	0.4(6)	-	0.8(4)	3.7(6)	4.0(6)	12.0(3)	7.5(2)	18.9(2)	-
51-100	317	14.487	64.9(4)	161.7(7)	30.2(8)	9.9(4)	5.1(4)	1.4(4)	51.3(4)	249.6(3)	318.4(2)	56.0(2)	34.2(3)
101-150	318	9.233	-	134.3(2)	1.8(2)	0.0(4)	1.9(2)	0.7(6)	10.9(2)	3.9(2)	8.9(2)	-	0.3(2)
51-100	319	73.863	14.0(4)	15.6(5)	61.2(2)	11.8(4)	63.0(4)	48.6(6)	34.2(4)	8.1(2)	39.3(4)	79.5(2)	33.0(7)
0- 30	320	99.085	-	2.7(2)	-	-	11.2(3)	-	-	-	12.3(6)	7.0(2)	18.8(4)
31- 50	321	89.251	90.5(2)	3.4(2)	-	-	88.5(2)	-	-	-	30.5(5)	45.5(2)	27.3(4)
51-100	322	117.626	-	-	-	-	75.1(4)	-	-	2.8(2)	67.1(8)	21.5(2)	58.0(8)
51-100	323	52.245	222.6(3)	-	-	-	111.0(4)	34.5(2)	-	-	162.5(3)	108.5(2)	256.5(2)
51-100	324	37.082	-	-	-	-	53.6(2)	-	-	4.0(2)	26.8(2)	-	71.3(2)
31- 50	325	70.861	-	-	-	-	60.4(2)	-	-	2.7(2)	7.7(4)	4.6(2)	41.4(5)
31- 50	326	12.461	-	-	-	-	-	-	-	15.7(2)	13.9(2)	1.9(2)	44.3(2)
151-200	705	14.638	0.9(2)	1.4(2)	0.8(4)	0.3(2)	2.2(2)	1.1(4)	0.2(3)	2.8(4)	0.5(2)	0.9(2)	0.6(2)
151-200	706	35.731	4.4(2)	8.2(2)	2.2(7)	-	-	3.1(4)	1.6(2)	5.6(3)	1.4(2)	6.8(2)	0.6(4)
151-200	707	6.981	14.9(2)	-	0.0(2)	0.4(4)	0.1(2)	0.1(4)	3.6(2)	2.1(2)	4.5(2)	-	-
201-300	708	8.783	-	-	-	0.0(3)	-	0.2(4)	-	0.5(2)	0.6(2)	-	-
301-400	709	7.206	-	-	-	-	-	-	-	-	-	-	-
301-400	710	2.702	-	-	-	-	-	-	-	-	-	-	-
201-300	711	72.137	-	-	-	-	-	-	-	-	0.2(2)	0.7(2)	0.0(2)
201-300	712	73.037	-	-	-	-	-	-	-	1.4(2)	0.0(2)	0.2(2)	0.0(3)
201-300	713	71.311	-	-	-	0.6(3)	-	-	-	-	0.2(2)	0.9(6)	0.3(2)
201-300	714	89.702	-	-	-	-	-	-	-	-	1.0(2)	0.1(8)	0.0(6)
151-200	715	9.908	0.0(2)	-	0.0(4)	0.0(2)	0.2(2)	0.2(4)	0.3(4)	0.4(3)	0.5(2)	0.3(2)	0.2(2)
151-200	716	40.460	0.0(2)	-	0.1(3)	-	-	0.9(6)	0.4(4)	2.1(4)	0.5(2)	1.8(4)	0.4(2)
Mean (No. sets)			56.8(42)	26.8(48)	25.2(79)	5.1(60)	42.3(66)	15.8(102)	8.6(61)	9.5(78)	27.8(80)	21.0(80)	30.7(91)
Biomass (t) from surveyed strata			33,826	13,654	12,999	1,901	37,757	9,109	3,785	7,236	35,776	25,974	39,076

Table 5. (Cont'd.)

Depth (fm)	Stratum	Year - Survey 1983 AN 9	1984 AN 26	1985 WT 26	1986 WT 45	1987 WT 55,56	1988 WT 68	1989 WT 81	1990 WT 91	1991 WT 103	1992 WT 118	1993(Feb) WT 133	1993 (Apr) WT 135	1994 WT 150-151*	1995 WT 166-167*
101-150	306	0.2(4)	0.1(2)	2.7(2)	0.6(3)	0.2(4)	0.3(4)	0.8(3)	0.1(3)	0.0(4)	0.3(2)	0.1(4)	0.2(4)		
51-100	307	1.3(4)	0.0(2)	0.1(3)	1.0(3)	0.4(3)	0.9(4)	0.1(3)	0.2(3)	0.0(3)	0.9(2)	0.1(4)	0.5(3)		
31- 50	308	101.2(3)	1.5(2)	3.7(2)	0.0(2)	0.0(2)	0.5(2)	0.0(2)	0.0(2)	0.0(2)	0.5(2)	0.0(2)	0.6(2)		
101-150	309	0.3(3)	7.3(2)	1.6(3)	0.2(2)	0.5(2)	1.1(3)	0.1(2)	1.2(2)	0.9(3)	1.3(2)	0.8(3)	0.7(2)		
101-150	310	0.2(3)	0.5(2)	4.2(3)	2.0(2)	3.5(2)	5.7(3)	10.3(2)	14.8(2)	3.6(2)	2.7(2)	2.6(2)	3.1(2)		
51-100	311	2.0(3)	2.6(2)	16.2(4)	77.0(3)	27.0(2)	74.1(4)	3.4(3)	15.2(3)	3.8(3)	0.2(2)	1.9(3)	3.9(2)		
31- 50	312	12.2(3)	0.6(2)	1.5(2)	4.0(2)	2.8(2)	0.0(2)	1.5(3)	6.9(3)	0.2(2)	5.4(2)	0.0(2)	2.1(2)		
101-150	313	2.9(3)	0.7(2)	0.9(2)	9.7(2)	1.6(2)	8.5(2)	9.3(2)	71.8(2)	52.4(2)	25.4(2)	2.8(2)	13.6(2)		
0- 30	314	11.9(7)	5.3(4)	0.5(7)	2.0(8)	6.0(5)	0.0(7)	0.9(9)	0.7(6)	2.4(7)	0.2(5)	0.0(6)	0.2(7)		
31- 50	315	61.4(8)	35.3(5)	40.9(7)	62.5(6)	33.1(8)	39.5(6)	14.6(7)	1.2(2)	9.4(7)	2.7(7)	0.4(5)	8.1(5)		
101-150	316	5.3(4)	1.7(2)	3.8(3)	7.0(2)	196.8(3)	19.8(3)	25.1(3)	8.2(2)	163.1(2)	188.9(2)	-	17.6(3)		
51-100	317	52.0(3)	6.0(2)	1312.8(2)	29.3(2)	80.0(3)	62.5(2)	151.8(2)	71.3(2)	8.7(2)	32.4(2)	12.0(2)	4.7(2)		
101-150	318	3.6(3)	7.3(2)	-	7.0(2)	37.1(2)	70.0(2)	2.0(2)	-	71.2(2)	53.0(2)	12.6(2)	47.0(2)		
51-100	319	112.1(7)	43.3(6)	26.5(2)	27.1(8)	104.3(9)	8.9(8)	33.7(8)	-	54.5(9)	10.9(10)	3.9(9)	6.9(6)		
0- 30	320	34.0(14)	9.4(8)	38.3(5)	17.0(9)	7.0(11)	4.5(11)	2.6(10)	1.4(5)	0.9(12)	1.1(9)	1.3(5)	6.6(8)		
31- 50	321	47.2(10)	28.0(6)	23.1(7)	26.9(10)	21.8(10)	5.7(11)	53.7(9)	1.7(8)	1.0(11)	0.8(9)	0.4(6)	1.9(8)		
51-100	322	71.2(11)	64.3(8)	179.2(13)	55.5(12)	22.9(10)	9.4(12)	5.2(14)	2.2(16)	7.7(14)	0.3(8)	0.2(12)	0.8(12)		
51-100	323	125.7(6)	44.4(4)	68.0(3)	170.5(5)	164.8(6)	324.0(5)	52.6(7)	19.1(4)	10.1(6)	1.6(6)	0.7(7)	0.7(4)		
51-100	324	91.5(4)	15.5(3)	202.3(2)	7.5(5)	95.7(4)	0.3(4)	11.5(5)	8.5(5)	8.5(4)	0.2(5)	0.0(3)	0.8(4)		
31- 50	325	53.4(8)	27.0(5)	25.7(3)	6.5(8)	1.6(6)	2.6(6)	6.1(8)	0.3(2)	1.8(9)	0.3(10)	0.2(9)	0.1(6)		
31- 50	326	40.8(3)	29.8(2)	-	8.0(2)	14.3(2)	0.6(2)	36.7(2)	1.1(2)	0.2(2)	0.8(2)	0.2(2)	0.0(2)		
151-200	705	0.5(3)	0.4(2)	3.5(2)	2.2(2)	3.5(2)	6.5(2)	13.0(2)	1.8(2)	1.7(2)	5.6(2)	4.4(2)	2.7(2)		
151-200	706	1.9(5)	0.3(2)	1.8(4)	7.3(4)	9.7(5)	3.4(4)	3.3(4)	9.0(4)	5.3(4)	7.6(5)	9.2(3)	25.7(5)		
151-200	707	0.0(3)	8.1(2)	-	4.0(2)	1.0(2)	5.2(2)	0.1(2)	-	39.8(2)	23.2(2)	8.7(2)	23.0(2)		
201-300	708	0.2(2)	1.4(2)	-	3.6(2)	1.5(2)	0.0(2)	3.0(2)	-	21.8(2)	6.3(2)	18.29(0)	4.8(2)		
301-400	709	0.2(2)	0.0(2)	-	-	-	-	7.0(2)	-	4.0(2)	-	4.0(2)	3.7(2)		
301-400	710	0.0(3)	2.5(2)	1.3(2)	0.7(2)	-	18.0(2)	-	-	9.2(2)	-	57.1(2)	0.0(2)		
201-300	711	0.8(8)	0.9(5)	1.0(8)	1.4(9)	2.2(7)	3.3(7)	1.7(7)	1.1(3)	1.9(8)	2.6(10)	0.9(5)	1.0(5)		
201-300	712	0.9(7)	-	1.0(6)	0.4(9)	0.3(4)	1.9(7)	1.9(8)	4.9(5)	0.6(8)	1.4(10)	1.5(7)	0.3(7)		
201-300	713	0.4(7)	-	0.4(8)	0.1(5)	1.0(4)	1.1(7)	1.2(8)	0.2(7)	4.5(8)	2.4(10)	1.8(8)	0.3(6)		
201-300	714	0.3(10)	-	-	8.8(5)	0.5(4)	1.8(9)	0.8(10)	0.8(7)	1.0(11)	0.7(7)	0.1(11)	0.1(9)		
151-200	715	0.8(3)	0.0(2)	-	1.8(2)	0.4(2)	0.0(2)	0.1(2)	2.3(2)	0.1(2)	0.5(2)	0.1(2)	1.1(4)		
151-200	716	1.5(4)	0.2(3)	4.2(5)	1.8(4)	3.8(3)	6.6(5)	1.5(4)	4.9(5)	1.3(5)	6.1(3)	7.7(4)	1.9(4)		
Mean (No. sets)		34.7(171)	20.8(95)	54.9(110)	23.2(144)	25.9(134)	20.8(152)	12.9(157)	4.8(109)	9.2(164)	5.2(147)	1.8(141)	3.4(138)	2.8(172)	2.9(164
Biomass (t) from surveyed strata		45,200	22,549	64,494	30,450	33,923	27,326	17,004	5,835	12,119	6,838	2,407	4,547	4,156	3,944

*New stratification schemes.

Table 6. Mean weight (kg) of American plaice per tow, by stratum, from r.v. surveys in Subdivision 3Ps in 1994. Numbers in parenthese are the number of successful 30-minute tows in each stratum. The stratified mean weight per tow and the biomass estimate are given at the bottom of the table. WT refers to the research vessel W. TEMPLEMAN).

Depth (fath)	Stratum	No. of trawl units ('000)	WT 150-151
101-150	306	31.452	0.2 (4)
51-100	307	29.650	0.4 (4)
31-50	308	8.407	0.0 (2)
101-150	309	22.219	0.0 (3)
101-150	310	12.761	6.2 (3)
51-100	311	23.795	30.2 (4)
31-50	312	20.417	19.5 (2)
101-150	313	12.386	30.8 (2)
0-30	314	73.113	.6 (9)
31-50	315	62.078	1.8 (6)
101-150	316	14.187	27.0 (2)
51-100	317	14.487	0.1 (2)
101-150	318	9.683	13.1 (2)
51-100	319	73.863	0.1 (9)
0-30	320	99.085	0.7 (8)
31-50	321	89.251	0.0 (10)
51-100	322	117.626	0.3 (13)
51-100	323	52.245	1.0 (6)
51-100	324	37.082	0.3 (3)
31-50	325	70.861	0.4 (8)
31-50	326	12.461	0.0 (2)
151-200	705	14.638	3.4 (3)
151-200	706	35.731	9.9 (4)
151-200	707	5.555	2.8 (2)
201-300	708	9.458	95.9 (2)
301-400	709	11.860	0.2 (2)
401-500	710	13.211	1.4 (2)
201-300	711	72.137	0.7 (6)
201-300	712	73.037	0.6 (7)
201-300	713	71.311	0.8 (7)
201-300	714	89.702	0.1 (8)
151-200	715	9.908	0.8 (4)
151-200	716	40.460	1.7 (5)
101-150	779	31.677	2.1 (4)
101-150	780	30.251	0.9 (4)
51-100	781	33.479	0.0 (4)
51-100	782	13.737	0.7 (2)
31-50	783	17.190	0.4 (2)
Mean (No. sets)			2.8 (172)
Biomass (t) from surveyed strata			4,156

Table 7. Mean weight (kg) of American plaice per tow, by stratum, from r.v. surveys in Subdivision 3Ps in 1995. Numbers in parenthese are the number of successful 30-minute tows in each stratum. The stratified mean weight per tow and the biomass estimate are given at the bottom of the table. WT refers to the research vessel W. TEMPLEMAN).

Depth (fath)	Stratum	No. of trawl units ('000)	WT 166-167
101-150	306	27.248	0.0 (3)
51-100	307	29.650	0.0 (4)
31-50	308	8.407	0.0 (2)
101-150	309	22.219	0.0 (3)
101-150	310	12.761	0.0 (2)
51-100	311	23.795	0.0 (3)
31-50	312	20.417	0.0 (3)
101-150	313	12.386	0.0 (2)
0-30	314	73.113	0.0 (7)
31-50	315	62.078	4.9 (7)
101-150	316	14.187	55.6 (2)
51-100	317	14.487	8.3 (2)
101-150	318	9.683	54.2 (2)
51-100	319	73.863	3.0 (8)
0-30	320	99.085	1.0 (12)
31-50	321	89.251	0.0 (11)
51-100	322	117.626	0.0 (13)
51-100	323	52.245	0.5 (5)
51-100	324	37.082	0.0 (4)
31-50	325	70.861	0.2 (7)
31-50	326	12.461	0.2 (2)
151-200	705	14.638	0.0 (2)
151-200	706	35.731	11.3 (4)
151-200	707	5.555	107.2 (2)
201-300	708	9.458	19.8 (2)
301-400	709	11.034	51.3 (2)
201-300	711	44.513	1.3 (5)
201-300	712	54.872	0.4 (7)
201-300	713	63.880	0.0 (8)
201-300	714	78.592	0.0 (10)
151-200	715	9.608	0.0 (2)
151-200	716	40.460	0.0 (5)
101-150	779	31.677	0.4 (4)
101-150	780	30.251	0.0 (2)
51-100	781	33.479	0.0 (3)
51-100	782	13.737	0.0 (2)
Mean (No. sets)			2.9 (164)
Biomass (t) from surveyed strata			3,944

Table 8. Biomass (tons) by depth category of American plaice from research vessel surveys in Subdivision 3Ps from 1972-1995.

Depth (fath)	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
0-30	2091	268	15	0	1190	1192	0	0	1255	716	3566	4239	1319
31-50	17622	3308	7514	521	14766	2102	0	724	6461	9060	9766	13416	7000
51-100	13797	6091	5333	1236	21689	5538	3413	5656	27521	15146	25938	27455	13805
101-150	52	3678	45	94	74	109	275	408	309	625	55	160	272
151-200	274	313	94	7	35	166	104	345	114	332	48	144	81
201-300	0	0	0	43	0	2	0	107	124	138	21	181	77
301-400	0	0	0	0	0	0	0	0	0	0	0	1	7
401-500	0	0	0	0	0	0	0	0	0	0	0	0	0

1985	1986	1987	1988	1989	1990	1991	1992	1993f	1993a	1994	1995
3832	1831	1132	446	323	146	265	124	129	669	113	99
6484	6923	4349	3157	6619	402	807	385	77	727	545	321
53497	20002	24370	21397	8558	2972	5991	1432	570	846	848	368
239	333	3216	1139	649	1224	3686	3557	205	913	1070	1326
285	412	563	520	371	569	546	767	766	1206	496	999
174	958	310	617	445	523	783	579	472	170	1067	267
4	2	0	49	50	0	54	0	183	27	2	566
0	0	0	0	0	0	0	0	0	0	18	0

note: stratification scheme was changed in 1994 and 1995.

Table 9. ABUNDANCE (MILLIONS) OF PLAICE FROM SURVEYS IN 3PS

AGE	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1993
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.02	0.00	0.05	0.49	0.09	0.07	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.01	0.00	0.00
3	0.68	0.39	0.20	2.35	0.57	1.56	0.16	0.00	0.02	0.05	0.12	0.07	0.11	0.02	0.15	0.02	0.01	0.00
4	1.85	0.43	0.84	3.15	3.59	6.73	1.20	0.19	0.42	0.64	0.38	0.46	0.47	0.24	0.34	0.06	0.03	0.01
5	5.14	2.03	1.97	7.98	4.29	8.87	7.12	1.95	2.74	2.18	1.95	2.48	1.23	0.97	1.34	0.59	0.09	0.29
6	3.62	3.19	3.28	12.75	6.89	10.72	16.65	7.56	7.63	8.71	5.52	8.00	3.74	1.07	2.74	1.46	0.83	1.69
7	6.90	4.69	8.80	32.62	14.25	15.66	19.61	9.03	14.50	15.21	11.87	10.30	6.03	1.74	4.07	2.66	1.25	2.38
8	6.85	5.98	7.77	31.35	19.16	22.17	18.78	8.15	10.35	10.68	14.89	13.76	4.85	1.94	5.33	1.65	1.03	1.78
9	5.09	6.52	4.17	21.89	12.67	27.33	16.01	6.57	10.48	5.88	9.66	7.35	4.49	2.00	4.16	1.58	0.76	1.37
10	3.83	2.88	1.57	14.02	7.33	13.25	7.99	5.44	9.39	4.68	6.86	4.59	2.54	1.49	3.05	1.26	0.48	0.71
11	2.97	3.07	1.29	5.64	2.92	5.54	5.15	2.99	5.61	2.71	3.19	1.95	1.64	0.91	1.34	0.72	0.27	0.45
12	1.59	2.21	1.17	3.49	2.41	4.57	2.72	1.67	3.89	2.26	2.80	1.36	1.49	0.56	1.12	0.51	0.14	0.20
13	0.42	1.03	0.62	1.57	1.04	2.25	1.74	0.70	3.81	1.67	1.77	0.75	1.03	0.23	0.74	0.52	0.07	0.19
14	0.60	0.37	0.38	0.77	0.89	1.43	1.06	0.49	2.62	0.89	1.13	0.59	0.59	0.27	0.37	0.23	0.03	0.13
15	0.14	0.12	0.30	0.09	0.32	0.70	0.67	0.34	2.53	0.94	0.99	0.54	0.38	0.26	0.47	0.40	0.04	0.10
16	0.11	0.35	0.18	0.42	0.48	0.52	0.70	0.15	2.14	0.62	0.67	0.31	0.46	0.20	0.40	0.18	0.02	0.06
17	0.04	0.08	0.03	0.11	0.17	0.31	0.22	0.11	1.17	0.24	0.22	0.25	0.19	0.12	0.11	0.08	0.01	0.02
18	0.01	0.00	0.00	0.23	0.33	0.57	0.13	0.08	1.29	0.18	0.14	0.03	0.13	0.10	0.03	0.04	0.01	0.00
19	0.01	0.00	0.00	0.06	0.22	0.04	0.11	0.01	0.07	0.03	0.03	0.01	0.05	0.04	0.01	0.01	0.00	0.00
1+	39.86	33.34	32.83	138.98	77.61	122.28	100.04	45.44	78.67	57.56	62.18	52.81	29.44	12.16	25.81	11.98	5.06	9.48
2+	39.86	33.34	32.83	138.98	77.61	122.28	100.04	45.44	78.67	57.56	62.18	52.81	29.44	12.16	25.81	11.98	5.06	9.48
3+	39.84	33.34	32.78	138.49	77.52	122.21	100.04	45.43	78.67	57.56	62.18	52.81	29.44	12.15	25.77	11.97	5.06	9.48
4+	39.16	32.95	32.57	136.14	76.95	120.65	99.88	45.43	78.65	57.51	62.06	52.74	29.33	12.13	25.62	11.95	5.05	9.48
5+	37.31	32.52	31.53	132.99	73.36	113.92	98.68	45.24	78.23	56.87	61.68	52.28	28.86	11.88	25.28	11.89	5.02	9.47
6+	32.17	30.49	29.56	125.02	69.07	105.06	91.56	43.29	75.49	54.69	59.73	49.80	27.63	10.91	23.94	11.30	4.93	9.08
7+	28.56	27.30	26.28	112.26	62.18	94.34	74.90	35.73	67.86	45.98	54.21	41.80	23.89	9.85	21.20	9.84	4.10	7.39
8+	21.66	22.61	17.47	79.64	47.93	78.68	55.29	26.70	53.36	30.77	42.34	31.50	17.85	8.11	17.13	7.18	2.85	5.01
9+	14.80	16.64	9.71	48.29	28.78	56.51	36.51	18.54	43.01	20.10	27.46	17.73	13.00	6.17	11.80	5.53	1.82	3.23
10+	9.71	10.11	5.54	26.40	16.10	29.18	20.49	11.97	32.53	14.22	17.80	10.38	8.51	4.18	7.64	3.95	1.06	1.86
11+	5.88	7.24	3.97	12.37	8.78	15.92	12.50	6.53	23.14	9.54	10.94	5.79	5.96	2.68	4.59	2.69	0.58	1.15
12+	2.91	4.17	2.68	6.74	5.86	10.39	7.35	3.55	17.52	6.83	7.75	3.84	4.32	1.78	3.25	1.97	0.31	0.70
13+	1.32	1.96	1.51	3.25	3.45	5.82	4.63	1.88	13.63	4.57	4.95	2.48	2.83	1.21	2.13	1.46	0.17	0.50

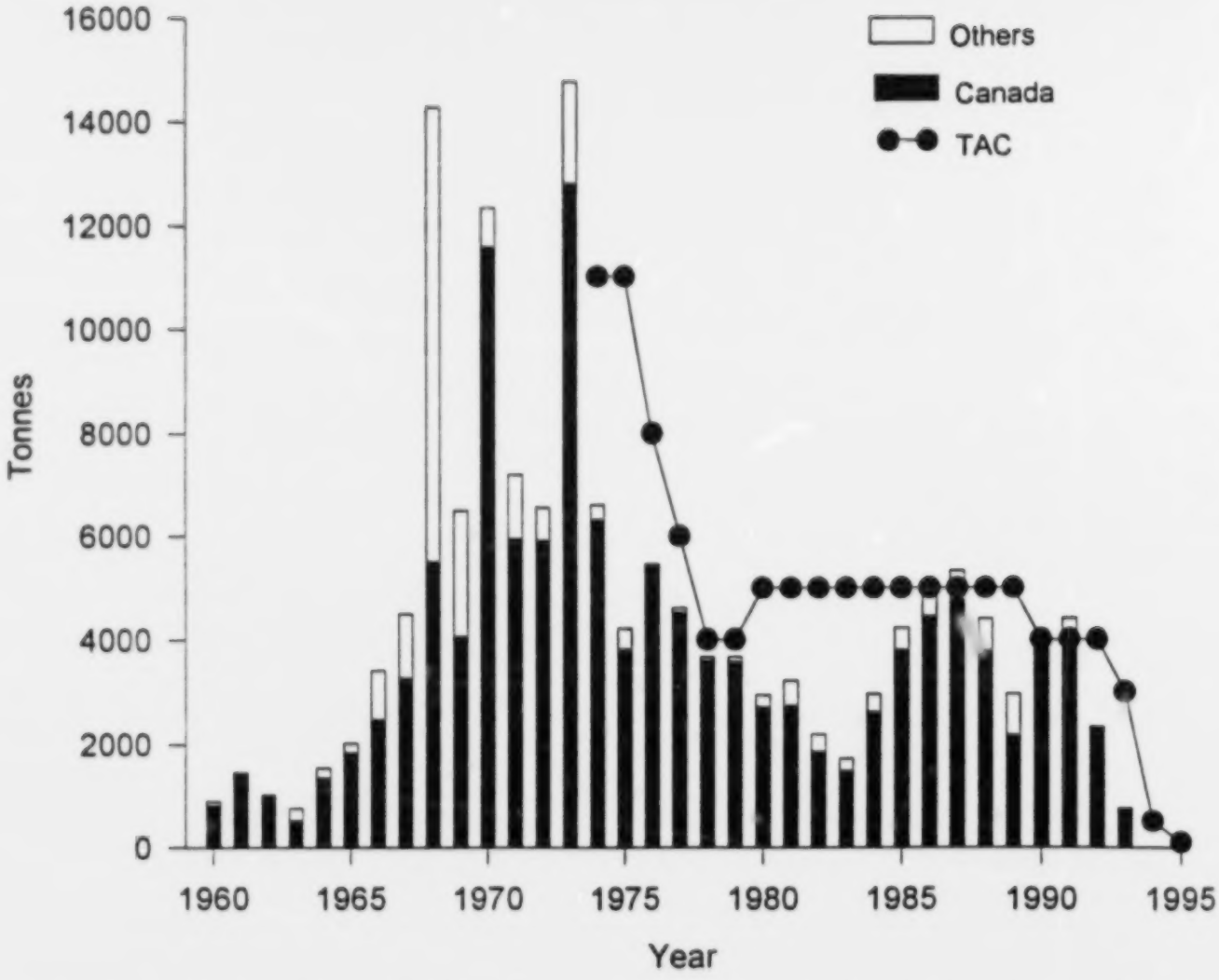

Figure 1. Total catch by Canada (black bars) and other countries (white bars) as well as the total allowable catch (TAC) for each year from 1960 to 1995.

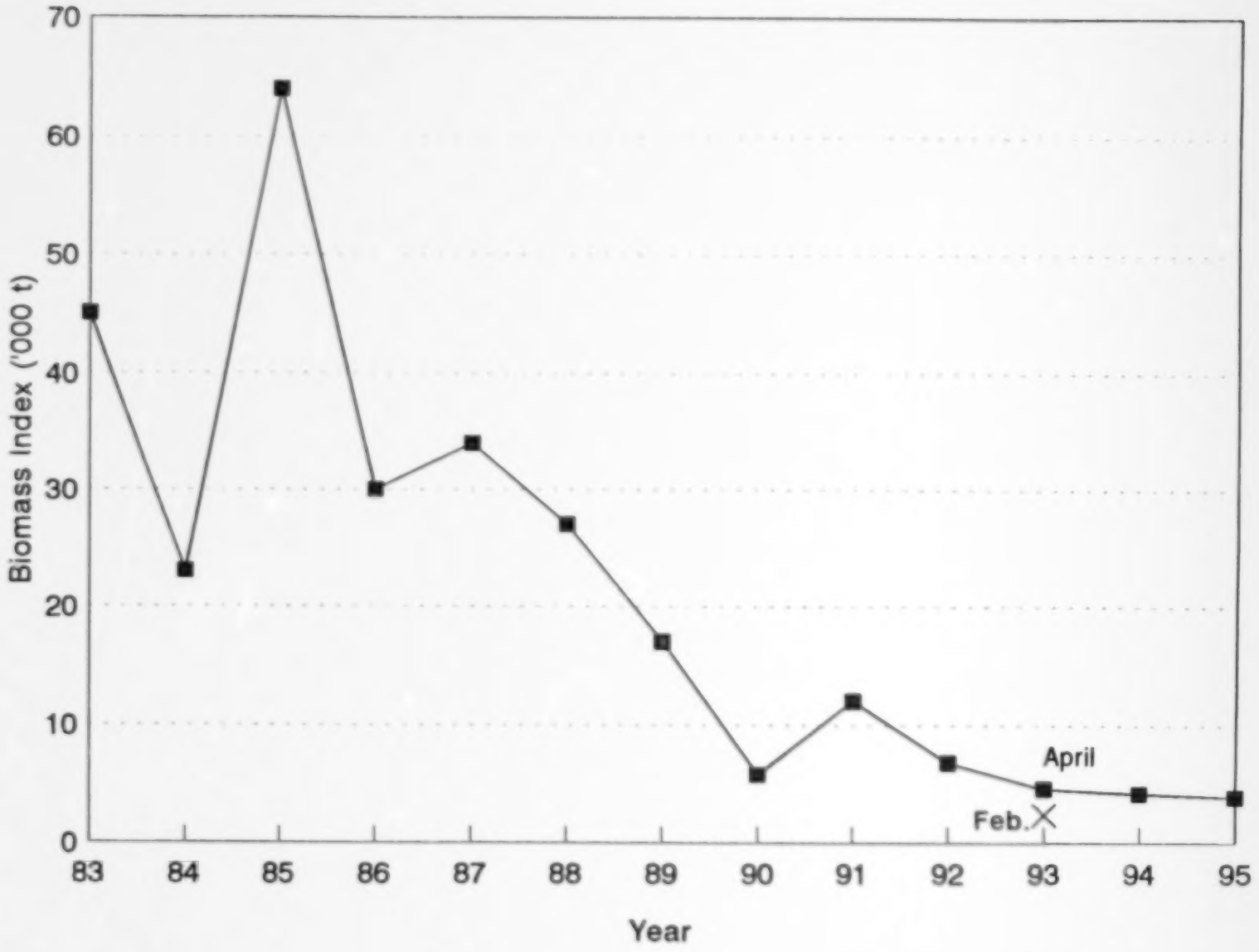

Figure 2. Biomass index of A.plaice from RV surveys in Subdiv. 3Ps from 1983-1995.

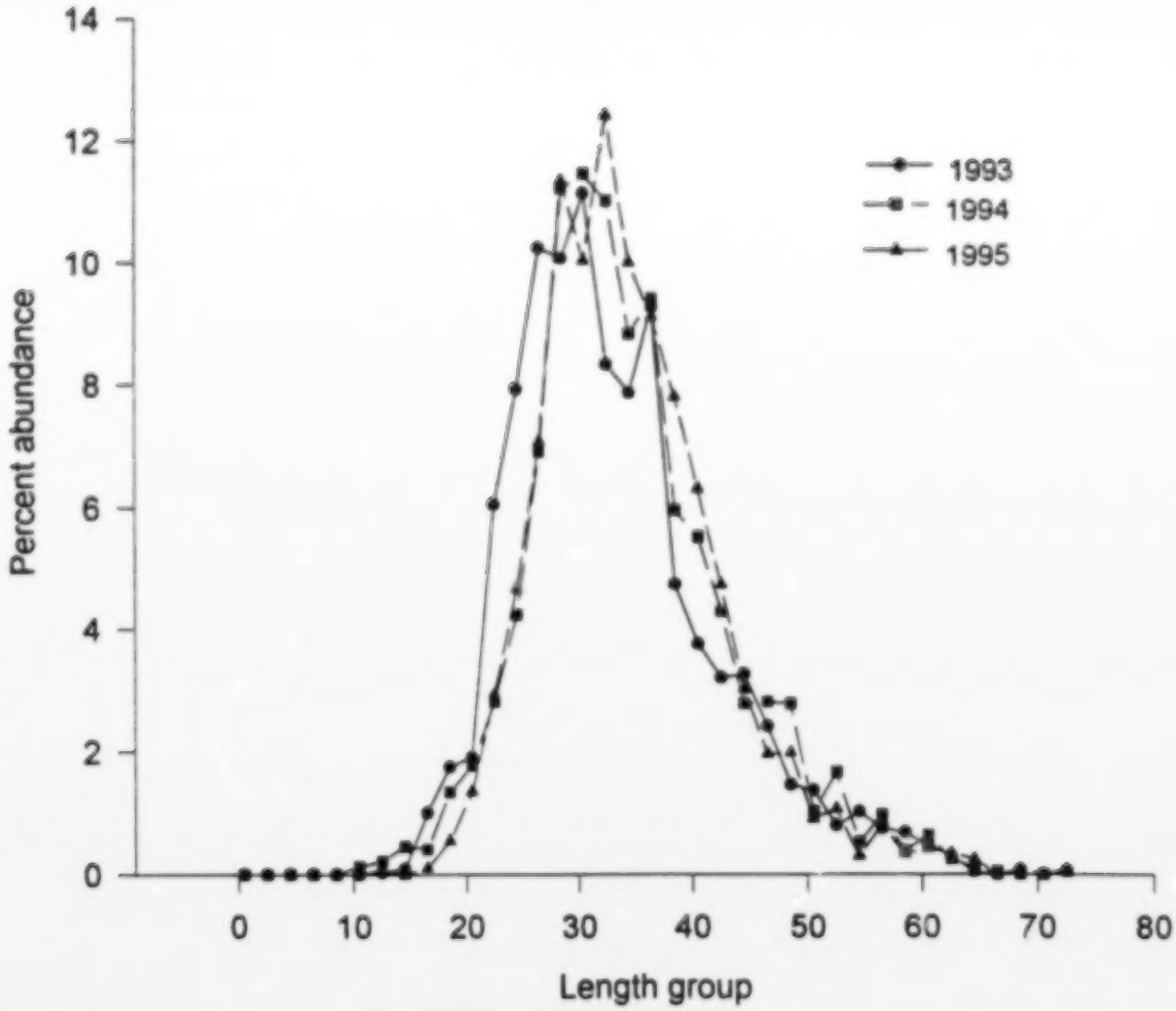

Figure 3. Percent abundance at length of A. plaice in subdivision 3Ps from research vessel surveys in 1993, 1994 and 1995.

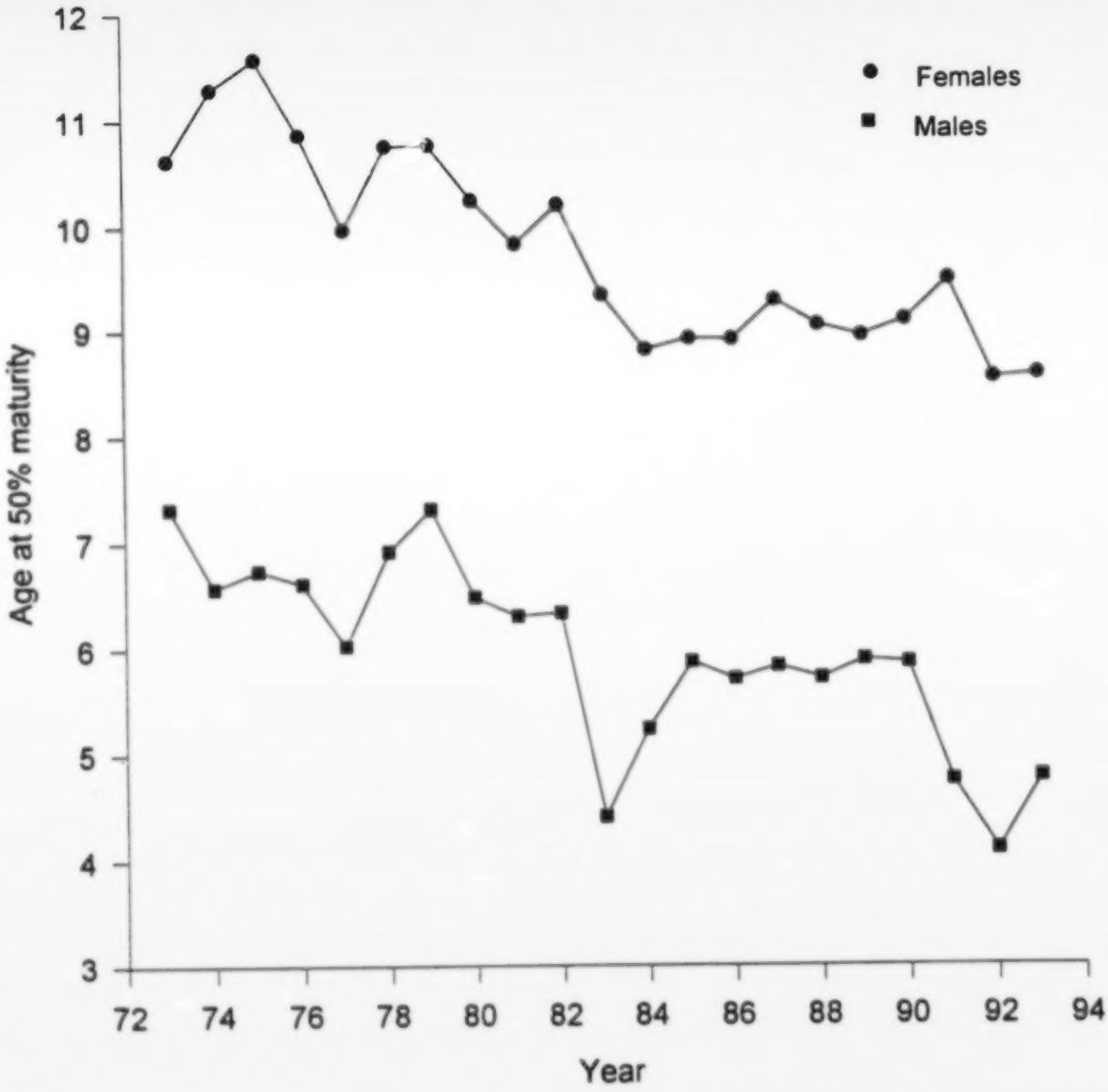

Figure 4. Age at 50% maturity of male and female American plaice in subdivision 3Ps

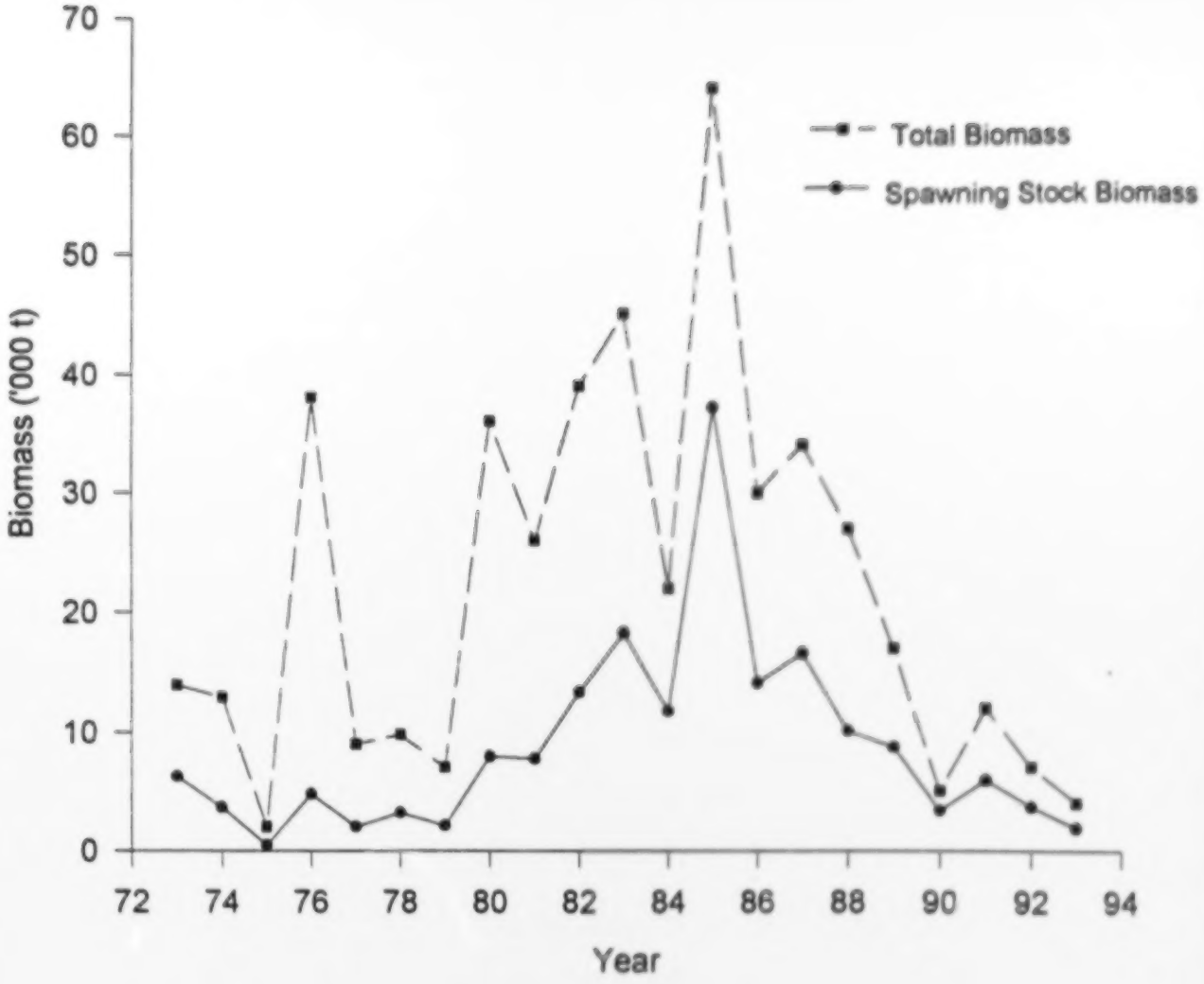

Figure 5. Total biomass and females spawning stock biomass from research vessel surveys

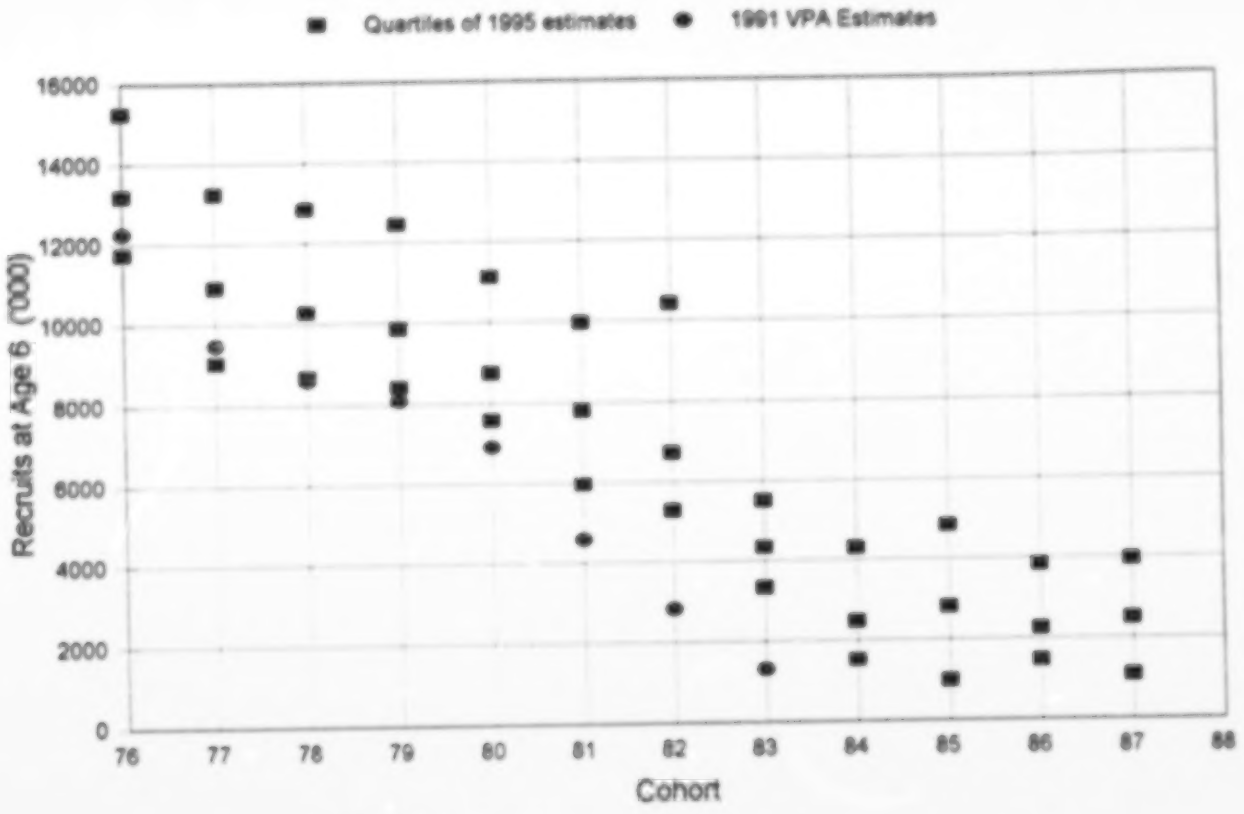

Figure 6. 3Ps plaice : Recruits (age 6) from 2 different SPA techniques.

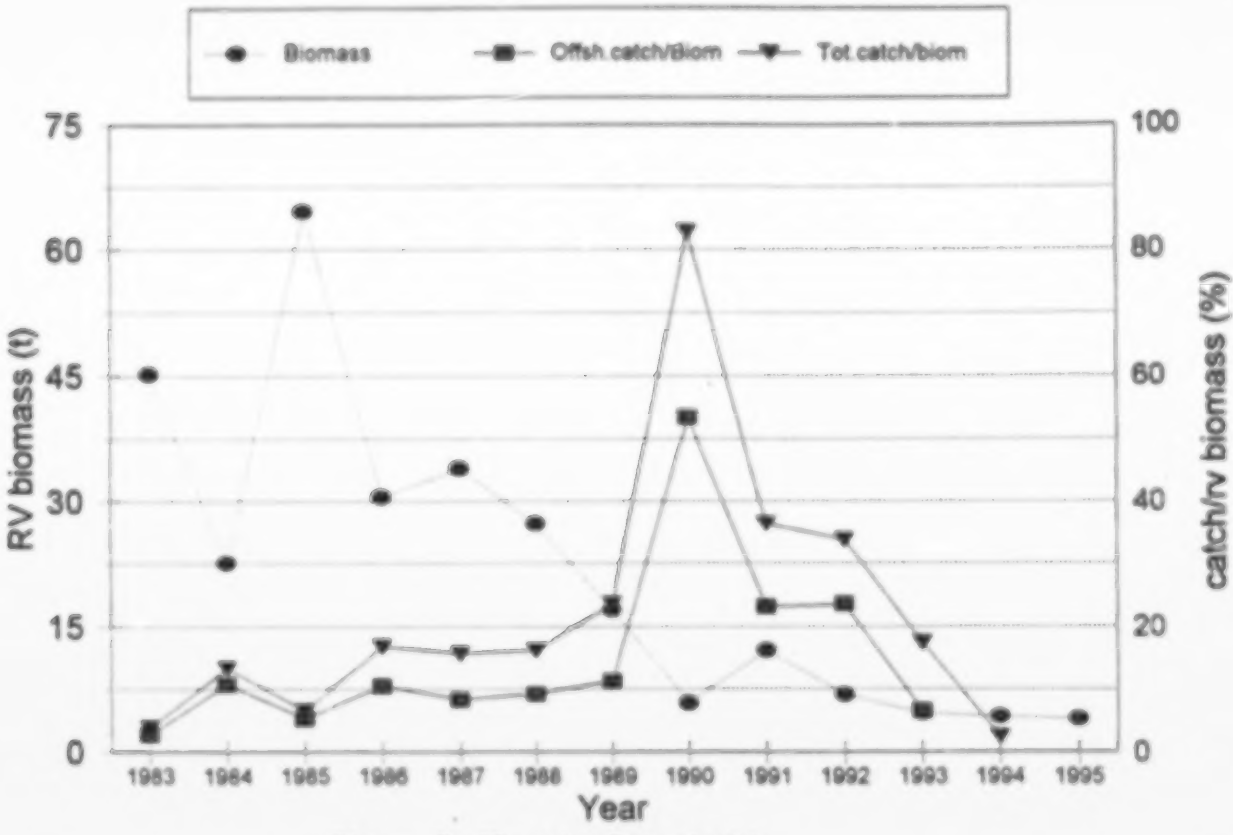

Figure 7. 3Ps plaice: Ratio of catch (offshore & total) to RV biomass index

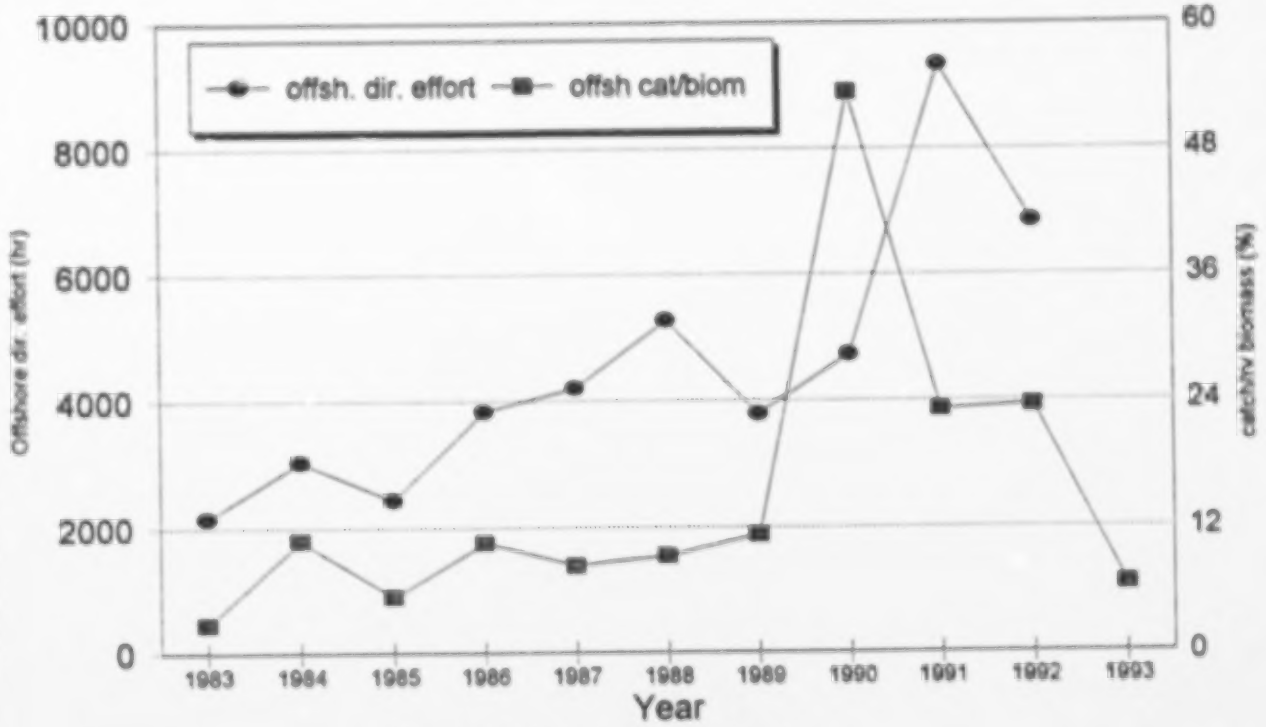

Figure 8. 3Ps plaice: Trends in effort and catch/biomass ratio.